

Gulf Stream ID Task Study

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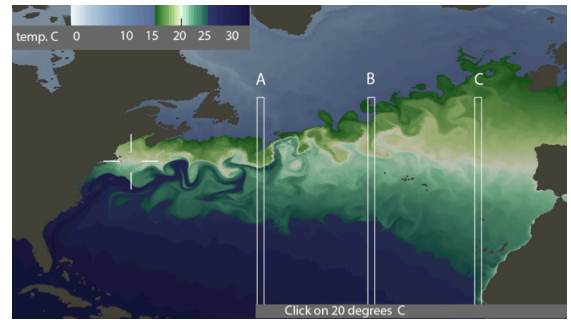
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Background:

A critical need for the climate domain scientist is the ability to see structures and features within the data. While the blue/green asymmetric divergent colormap was able to show the Gulf Stream in more detail than previously available, further discussion between artist and scientist led to the development of nested colormaps: inserting a complete colorscale over a very narrow range in that data, overlaid on a neutral background colorscale. This allowed the scientist to highlight a very specific region of the data. The user study described here was designed to test a domain scientist exploratory task: identify and follow the location of the Gulf Stream across a range of latitudes.

Hypothesis:

Our hypothesis is that participants would be able to more consistently identify the location of the Gulf Stream in an image using the blue/green nested colormap than in other comparison colormaps.

Methodology:

In order to test how well people can identify a specific feature in the data, we created a user study with the hypothesis that participants would be able to more consistently identify the latitudinal (Y) location of the Gulf Stream at multiple longitudinal (X) points in a visualization using the blue/green nested colormap than in any other comparison colormap. The blue/green nested colormap was compared to the blue/green asymmetric divergent, the rainbow and the cool/warm colormaps.

For this study, the POP data was used to produce an image of the Gulf Stream, stretching from the east coast of the US to the west coast of Europe/Africa. Each image had a temperature scale with a tick mark at 20degC to identify the color associated with the Gulf Stream. Additionally, a set of crosshairs off the east coast of the US identified the start of the Gulf Stream and was a second method by which participants could identify the color associated with the Gulf Stream. Three narrow vertical boxes were shown in each image. The four images are shown in at the end of this summary. Participants were first shown an example image (in a different colormap) to describe the task and explain the temperature scale, the crosshairs and the vertical boxes. The four different colormap images were randomly presented using the Qualtrics Heat Map question type and the participants were asked to click once in each vertical box to identify the location of the Gulf Stream within that box. After viewing each image, a validation question required participants to select the color they had identified as the 20degC Gulf Stream temperature.

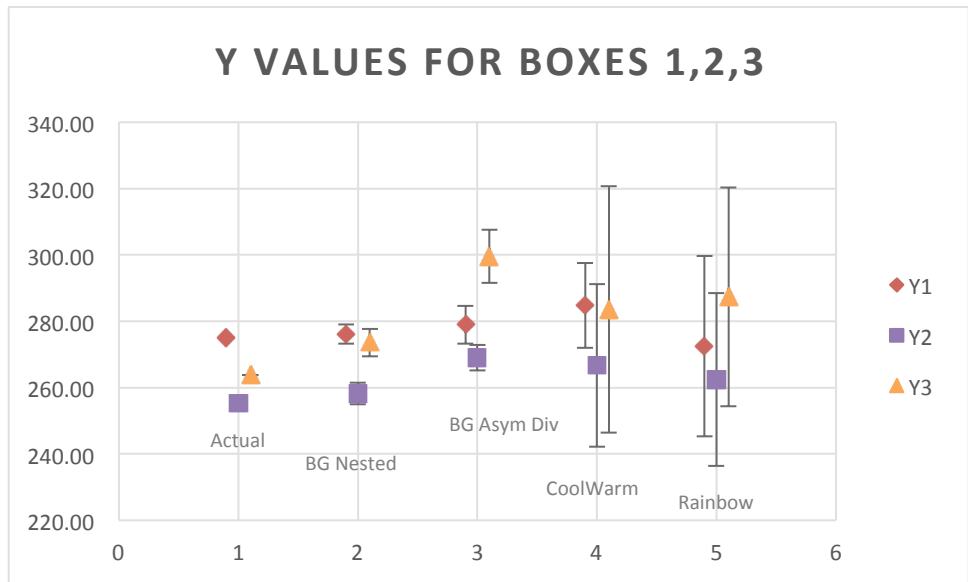
Participants were obtained through Amazon Mechanical Turk, a crowdsourcing site. Participants were screened out if they were colorblind (self-identification). Basic demographic information was collected (age, gender, education level).

Data Analysis:

In all, we had 43 valid participants in this study. Many participants self-selected out of the study after viewing the instructions. Additionally, each response was manually checked to verify that the participant understood the task and correctly clicked once in each box. We required that a participant had to correctly identify the color of the Gulf Stream in all four of the images to be considered a valid response.

The output from the Qualtrics heat map type question is a set of (X,Y) values for each click where the (X,Y) are with respect to the upper left hand corner. Because the vertical boxes are narrow, the X values are constrained to a small range. The Y values indicate the vertical position where the participant identified the 20degC point within each box.

We wanted to determine if the colormap made a difference in the ability of a participant to identify the location of the Gulf Stream. The analysis looks simply at the distribution of Y values for the three boxes (Y1, Y2, Y3) for each of the colormaps. Plotted in the following graph are the mean Y values for each box and the associated standard deviation is plotted as the error bars. As can be seen, the standard deviations of the Y values using the nested colormaps are much smaller than the standard deviations of the Y values using any of the other colormaps. There was much more consistent agreement within the participants on the location of the Gulf Stream across all three latitudes estimated when the nested colormap was used. The blue/green asymmetric divergent colormap also allowed participants to more closely select the location of the Gulf Stream.



The mean and standard deviations for each of the three boxes and each of the four colormaps is shown in this table:

	Y1 Mean	Y1 StDev	Y2 Mean	Y2 StDev	Y3 Mean	Y3 StDev
Actual Values	275.04	0.00	255.29	0.00	263.79	0.00
Blue/Green Nested	276.14	2.98	258.21	3.23	273.58	4.15
Blue/Green Divergent	278.95	5.71	269.08	3.89	299.56	8.07
CoolWarm	284.76	12.76	266.65	24.46	283.51	37.10
Rainbow	272.51	27.20	262.41	26.05	287.38	33.00

Ranking Ease of Task:

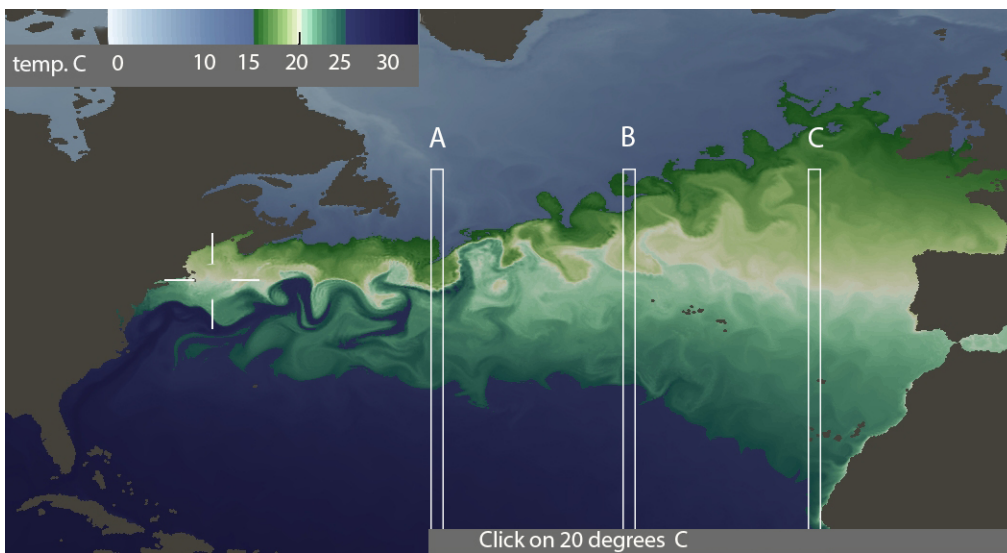
In addition to the Gulf Stream identification task, participants were asked to subjectively rank how difficult it was to identify the Gulf Stream in each of the four images. This question used a Qualtrics “drag and drop” rank order question. Participants were shown the four images in a vertical stack and asked to drag them around to order them easiest to hardest. Participants were shown the four images in one of six possible orders with the nested colormap never appearing in the initial (1) position. Participants were evenly split in considering it easiest to identify the Gulf Stream using the Nested colormap or the Blue/Green colormap.

Percentage Ranked:	1: Easiest	2	3	4: Hardest
Nested	31.8%	36.4%	6.8%	25.0%
BlueGreen	31.8%	29.5%	15.9%	22.7%
CoolWarm	15.9%	11.4%	34.1%	38.6%
Rainbow	20.5%	22.7%	43.2%	13.6%

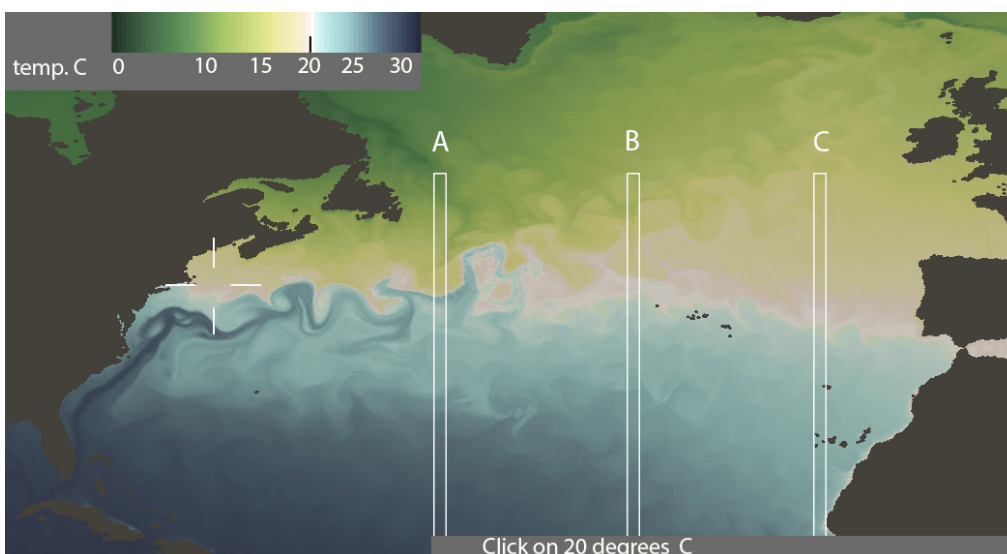
Conclusion:

In conclusion, participants were able to identify the location of the Gulf Stream more closely when it was displayed in either the blue/green nested or blue/green asymmetric divergent colormaps than in the standard cool/warm or rainbow colormaps.

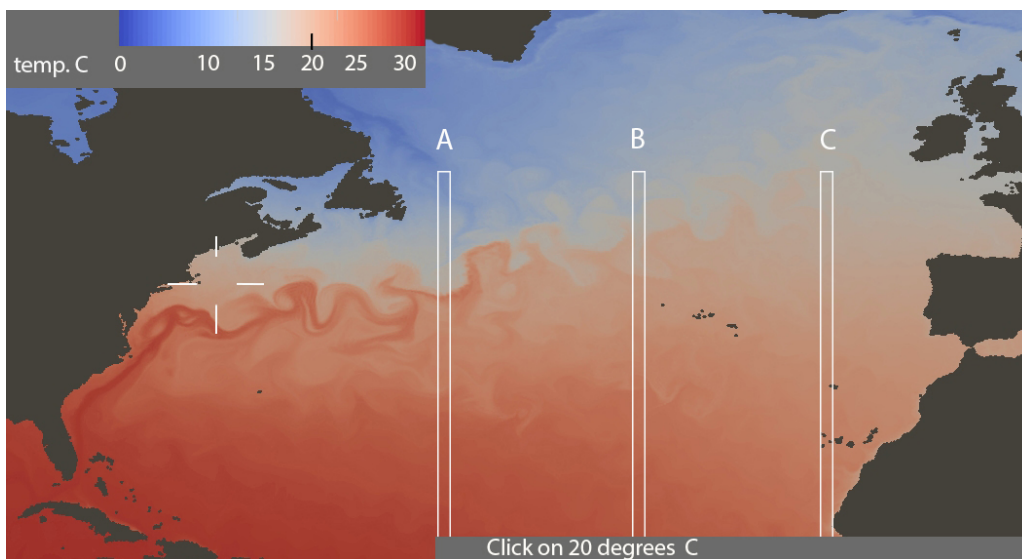
Gulf Stream in Nested Colormap:



Gulf Stream in Blue/Green Asymmetric Divergent Colormap:



Gulf Stream in Cool/Warm Colormap:



Gulf Stream in Rainbow Colormap:

